

CLAIMS

What is claimed is:

1. A method for use in communicating an orthogonal frequency division multiplexing (OFDM) signal, comprising the steps of:
 - receiving a burst with a system having L antenna branches and n radio frequency (RF) receivers, wherein the burst includes a diversity selection portion comprising one or more OFDM symbols that each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content;
 - taking a first set of measurements from a first of the L antenna branches on one or more of the non-zero OFDM frequency bins;
 - taking a second set of measurements from the first of the L antenna branches on one or more of the zero OFDM frequency bins; and
 - computing an estimate for carrier-to-noise-plus-interference ratio (CNIR) for at least one OFDM frequency bin of the first of the L antenna branches using the first and second set of measurements.
2. A method in accordance with claim 1, wherein the first and second set of measurements comprise power measurements.
3. A method in accordance with claim 1, wherein the first and second set of measurements comprise complex receiver fast Fourier transform (FFT) output values.
4. A method in accordance with claim 1, wherein the step of computing the estimate for the CNIR comprises the steps of:
 - estimating the CNIR for a respective OFDM frequency bin by:
 - summing respective ones of the first set of measurements within

a window centered about the respective OFDM frequency bin to form a first sum;

summing respective ones of the second set of measurements within a window centered about the respective OFDM frequency bin to form a second sum;

dividing the first sum by the second sum to form a first quotient;
and

subtracting 1 from the first quotient.

5. A method in accordance with claim 1 wherein the computing step comprises computing an estimate for carrier-to-noise-plus-interference ratio (CNIR) for each of the non-zero OFDM frequency bins and each of the zero OFDM frequency bins of the first of the L antenna branches using the first and second set of measurements.

6. A method in accordance with claim 1, further comprising the step of:

computing an average value over multiple bursts for the CNIR for the at least one OFDM frequency bin.

7. A method in accordance with claim 1, wherein the burst comprises a preamble portion and a data portion and the diversity selection portion follows the data portion.

8. A method in accordance with claim 1, wherein the one or more OFDM symbols comprise one or more OFDM symbols selected from a group consisting of: OFDM short symbols as defined in the IEEE 802.11a standard and OFDM short symbols as defined in the HiperLAN2 standard.

9. A method in accordance with claim 1, wherein the one or more OFDM symbols comprise OFDM symbols having alternating zero and non-zero frequency bin content throughout all subcarriers.

10. A method in accordance with claim 1, further comprising the steps of:

taking a third set of measurements from a second of the L antenna branches during one or more non-zero OFDM frequency bins;

taking a fourth set of measurements from the second of the L antenna branches during one or more zero OFDM frequency bins; and

computing an estimate for CNIR for at least one OFDM frequency bin of the second of the L antenna branches using the third and fourth set of measurements.

11. A method in accordance with claim 10, wherein the diversity selection portion further comprises one or more antenna branch probing portions, and the first and second set of measurements are taken by a first of the n RF receivers during a first antenna branch probing portion and the third and fourth set of measurements are taken by a second of the n RF receivers during the first antenna branch probing portion.

12. A method in accordance with claim 1, wherein:
the diversity selection portion further comprises one or more antenna branch probing portions;
and further comprising the step of,
computing estimates for CNIR for at least one OFDM frequency bin of additional ones of the L antenna branches by taking measurements from the additional ones of the L antenna branches n antenna branches at a time during different antenna branch probing portions.

13. A method for use in communicating an orthogonal frequency division multiplexing (OFDM) signal, comprising the steps of:
generating a burst having a preamble portion and a data portion;
adding a diversity selection portion to the burst, wherein the diversity selection portion includes one or more OFDM symbols that each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content; and
transmitting the burst including the diversity selection portion within a frame structure.

14. A method in accordance with claim 13, wherein the one or more OFDM symbols comprise one or more OFDM symbols selected from a group consisting of: OFDM short symbols as defined in the IEEE 802.11a standard and OFDM short symbols as defined in the HiperLAN2 standard.

15. A method in accordance with claim 13, wherein the one or more OFDM symbols comprise OFDM symbols having alternating zero and non-zero frequency bin content throughout all subcarriers.

16. A method in accordance with claim 13, wherein the diversity selection portion further comprises one or more antenna branch probing portions.

17. A method in accordance with claim 16, wherein the diversity selection portion further comprises one or more switching time intervals with one of the switching time intervals being located between two antenna branch probing portions.

18. A method in accordance with claim 13, wherein the preamble portion and the data portion are defined in accordance with the IEEE 802.11a standard.

19. A method in accordance with claim 13, wherein the preamble portion and the data portion are defined in accordance with the HiperLAN2 standard.

20. A method in accordance with claim 13, wherein the adding step comprises adding the diversity selection portion to the burst following the data portion.

21. A method in accordance with claim 13, wherein the adding step comprises adding the diversity selection portion to the burst positioned within the data portion.

22. A method in accordance with claim 13, wherein the adding step comprises adding the diversity selection portion to the burst following the preamble portion.

23. A method in accordance with claim 13, wherein the adding step comprises adding the diversity selection portion to the burst positioned within the preamble portion.

24. A communication burst embodied in an orthogonal frequency division multiplexing (OFDM) signal and transmitted within a frame structure, comprising:

a preamble portion including a plurality of OFDM symbols, the preamble portion including a coarse frequency estimation portion;

a data portion following the preamble portion and including a plurality of OFDM data symbols; and

a diversity selection portion comprising one or more antenna branch probing portions, the diversity selection portion occurring after the coarse frequency estimation portion of the preamble portion, wherein each of the one or more antenna branch probing portions includes one or more OFDM symbols.

25. A burst in accordance with claim 24, wherein each of the one or more OFDM symbols within each of the one or more antenna branch probing portions each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content.

26. A burst in accordance with claim 25, wherein each of the one or more OFDM symbols within each of the one or more antenna branch probing portions OFDM symbols selected from a group consisting of: OFDM short symbols as defined in the IEEE 802.11a standard and OFDM short symbols as defined in the HiperLAN2 standard.

27. A burst in accordance with claim 25, wherein each of the one or more OFDM symbols within each of the one or more antenna branch probing portions comprise OFDM symbols having alternating zero and non-zero frequency bin content throughout all subcarriers.

28. A burst in accordance with claim 24, wherein the diversity selection portion further comprises one or more switching time intervals with one of the switching time intervals being located between two antenna branch probing portions.

29. A burst in accordance with claim 24, wherein the preamble portion and the data portion are defined in accordance with a standard selected from a group consisting of: the IEEE 802.11a standard and the HiperLAN2 standard.

30. A burst in accordance with claim 24, wherein the diversity selection portion follows the data portion.

31. A burst in accordance with claim 24, wherein the diversity selection portion follows the preamble portion.

32. A burst in accordance with claim 24, wherein the diversity selection portion is positioned within the data portion.

33. A burst in accordance with claim 24, wherein the diversity selection portion is positioned within the preamble portion.

34. A burst in accordance with claim 24, wherein the diversity selection portion is configured for diversity antenna branch selection at a receiver receiving the communication burst based upon bin-by-bin measurements of the one or more OFDM symbols of the diversity selection portion.

35. A communication burst embodied in an orthogonal frequency division multiplexing (OFDM) signal and transmitted within a frame structure, comprising:

a preamble portion including a plurality of OFDM symbols;

a data portion following the preamble portion and including a plurality of OFDM data symbols; and

a diversity selection portion comprising one or more antenna branch probing portions, wherein each of the one or more antenna branch probing portions includes one or more OFDM symbols,

wherein the diversity selection portion is configured for diversity antenna branch selection at a receiver receiving the communication burst based upon bin-by-bin measurements of the one or more OFDM symbols of the diversity selection portion.

36. A burst in accordance with claim 35, wherein each of the one or more OFDM symbols within each of the one or more antenna branch probing portions each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content.

37. A burst in accordance with claim 39, wherein the diversity selection portion is located in a position within the communication burst selected from a group of positions consisting of: following the data portion, following the preamble portion, following a coarse frequency estimation portion of the preamble portion, within the data portion and within the preamble portion.

38. A medium access control (MAC) frame format embodied in an orthogonal frequency division multiplexing (OFDM) signal, comprising:

one or more communication bursts occupying different time portions of the frame format, each of the one or more communication bursts comprising:

a preamble portion including a plurality of OFDM symbols, the preamble portion including a coarse frequency estimation portion;

a data portion following the preamble portion and including a plurality of OFDM data symbols; and

a diversity selection portion comprising one or more antenna branch probing portions, the diversity selection portion occurring after the coarse frequency estimation portion of the preamble portion, wherein each of the one or more antenna branch probing portions includes one or more OFDM symbols.

39. A frame format in accordance with claim 38, wherein each of the one or more OFDM symbols within each of the one or more antenna branch probing portions of each of the one or more communication bursts each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content.

40. A frame format in accordance with claim 38, wherein the diversity selection portion of each of the one or more communication bursts is located in a position within the one or more communication bursts selected from a group of positions consisting of: following the data portion, following the preamble portion, within the data portion and within the preamble portion.

41. A method of performing diversity reception in radio frequency (RF) communications, comprising the steps of:

receiving a burst with a system having L antenna branches and n RF receivers, wherein L and n are variables and the burst includes a preamble portion, a data portion and a diversity selection portion, the diversity selection portion including one or more antenna branch probing portions, wherein each of the one or more antenna branch probing portions includes one or more OFDM symbols; and

taking measurements from n of the L antenna branches during one of the antenna branch probing portions.

42. A method in accordance with claim 41, wherein each of the one or more OFDM symbols within each of the one or more antenna probing portions each have a frequency bin structure that includes both non-zero and zero OFDM frequency bin content.

43. A method in accordance with claim 41, further comprising the step of:

taking measurements from a remainder of the L antenna branches by taking measurements from n antenna branches at a time during different antenna branch probing portions.

44. A method in accordance with claim 41, wherein the diversity selection portion further comprises one or more switching time intervals with one of the switching time intervals being located between two antenna branch probing portions, the method further comprising the step of:

switching to a different set of n of the L antenna branches during the one of the switching time intervals.

45. A method of performing diversity antenna selection, comprising the steps of:

taking measurements from L different antenna branches n antenna branches at a time; and

using the measurements to identify a group of n of the L different antenna branches that minimizes an approximate bit error probability of a subsequent signal that will eventually be constructed from sub-carriers that are each received by any one of the n antenna branches in the identified group of n antenna branches.

46. A method in accordance with claim 45, wherein the measurements comprise power measurements corresponding to each of K sub-carriers.

47. A method in accordance with claim 46, wherein the K sub-carriers form an orthogonal frequency division multiplexing (OFDM) signal.

48. A method in accordance with claim 46, wherein the step of using the measurements to identify a group of n of the L different antenna branches further comprises the step of:

computing an approximate bit error probability for each of the K sub-carriers for each of the L antenna branches n antenna branches at a time.

49. A method in accordance with claim 48, wherein the step of using the measurements to identify a group of n of the L different antenna branches further comprises the steps of:

forming different groupings of n antenna branches from among the L different antenna branches; and

for each different grouping of n antenna branches, selecting a minimum one of the approximate bit error probabilities for each one of the K sub-carriers.

50. A method in accordance with claim 49, wherein the step of using the measurements to identify a group of n of the L different antenna branches further comprises the step of:

for each different grouping of n antenna branches, summing the minimum ones of the approximate bit error probabilities that were selected for each one of the K sub-carriers.

51. A method in accordance with claim 50, wherein the step of using the measurements to identify a group of n of the L different antenna branches further comprises the steps of:

determining which sum of the minimum ones of the approximate bit error probabilities has a smallest value; and

selecting the grouping of n antenna branches that produced the sum of the minimum ones of the approximate bit error probabilities having the smallest value.

52. A method in accordance with claim 48, wherein the step of computing an approximate bit error probability for each of the K sub-carriers for each of the L antenna branches n antenna branches at a time further comprises the step of:

computing a detection statistic $\Lambda_{k,l}$ for each of the K sub-carriers for each of the L antenna branches n antenna branches at a time based on the power measurements.

53. A method in accordance with claim 52, wherein the step of computing an approximate bit error probability for each of the K sub-

carriers for each of the L antenna branches n antenna branches at a time further comprises the step of:

approximating a Q-function for each of the K sub-carriers for each of the L antenna branches n antenna branches at a time with a corresponding detection statistic comprising an argument thereof.

54. A method in accordance with claim 45, wherein the step of taking measurements from L different antenna branches n antenna branches at a time comprises the steps of:

receiving a burst that includes a diversity selection portion comprising one or more antenna branch probing portions; and

taking measurements from n antenna branches during one of the antenna branch probing portions.

55. A method in accordance with claim 54, wherein the step taking measurements from n antenna branches during one of the antenna branch probing portions comprises the step of:

taking measurements from each one of the n antenna branches with a separate one of n radio frequency receivers.

56. A method in accordance with claim 52, wherein the detection statistic is based upon a carrier-to-noise+interference ratio (CNIR) corresponding to each of the K sub-carriers.

57. A method in accordance with claim 45, further comprising the step of:

constructing an output signal from sub-carriers that are each received by any one of the n antenna branches in the identified group of n antenna branches.

58. A method in accordance with claim 57, wherein the step of constructing an output signal from sub-carriers comprises the steps of:

computing a detection statistic $\Lambda_{k,l}$ for each of K sub-carriers for each of the n antenna branches in the identified group of n antenna branches; and

comparing the detection statistics for each of the K sub-carriers for each of the n antenna branches in the identified group of n antenna branches with the detection statistics for each of the respective K sub-carriers for each of the other n antenna branches in the identified group of n antenna branches.

59. A method in accordance with claim 58, wherein the step of constructing an output signal from sub-carriers further comprises the step of:

based on results of the comparing step, selecting sub-carriers from one or more of the n antenna branches in the identified group of n antenna branches to form the output signal.

60. A method in accordance with claim 45, further comprising the step of:

using the measurements to determine an estimate of the carrier-to-noise+interference ratio (CNIR) for at least one frequency bin of one of the L antenna branches.

61. A diversity antenna selection module, comprising:
means for taking measurements from L different antenna branches n antenna branches at a time; and

means for using the measurements to identify a group of n of the L different antenna branches that minimizes an approximate bit error probability of a subsequent signal that will eventually be constructed from

sub-carriers that are each received by any one of the n antenna branches in the identified group of n antenna branches.

62. An apparatus that includes a diversity antenna selection module, wherein the diversity antenna selection module comprises:

a first computation stage configured to compute an approximate bit error probability for each of K sub-carriers of an OFDM signal received for each of L different antenna branches n antenna branches at a time; and

a second computation stage configured to process the approximate bit error probabilities to identify a group of n of the L different antenna branches that minimizes an approximate bit error probability of subsequent OFDM signals that will eventually be constructed from sub-carriers that are each received by any one of the n antenna branches in the identified group of n antenna branches.

63. An apparatus in accordance with claim 62, wherein the second computation stage further comprises:

a multiplexer configured to form different groupings of n antenna branches from among the L different antenna branches; and

a minimum function stage configured to select a minimum one of the approximate bit error probabilities for each one of the K sub-carriers of the OFDM signal received for each different grouping of n antenna branches.

64. An apparatus in accordance with claim 63, wherein the second computation stage further comprises:

a summation stage configured to sum the minimum ones of the approximate bit error probabilities that were selected for each one of the K sub-carriers of the OFDM signal received for each different grouping of n antenna branches.

65. An apparatus in accordance with claim 64, wherein the second computation stage further comprises:

a minimum metric selection stage configured to determine which sum of the minimum ones of the approximate bit error probabilities has a smallest value; and

a diversity antenna decision stage configured to select the grouping of n antenna branches that produced the sum of the minimum ones of the approximate bit error probabilities having the smallest value.

66. An apparatus in accordance with claim 62, wherein the first computation stage further comprises:

n detection statistic stages each configured to compute a detection statistic $\Lambda_{k,l}$ for each of K sub-carriers.

67. An apparatus in accordance with claim 66, wherein the detection statistic is based upon a carrier-to-noise+interference ratio (CNIR) corresponding to each of the K sub-carriers of the OFDM signal received for each of L different antenna branches n antenna branches at a time.

68. An apparatus in accordance with claim 66, wherein the detection statistic stages determine an estimate of the carrier-to-noise+interference ratio (CNIR) corresponding to at least one of the K sub-carriers of the OFDM signal received for each of L different antenna branches n antenna branches at a time.

69. An apparatus in accordance with claim 66, wherein the first computation stage further comprises:

n Q-function stages each configured to process detection statistics.

70. An apparatus in accordance with claim 61, further comprising:
n radio frequency receivers coupled to the diversity antenna selection module.

71. An apparatus in accordance with claim 61, further comprising:
an antenna selection stage configured to allow each of n different radio frequency receivers to be coupled to any one of the L different antenna branches.


72. An apparatus in accordance with claim 62, further comprising:
a diversity antenna structure having L different antenna branches.

73. An apparatus in accordance with claim 62, further comprising:
a sub-carrier selection diversity module configured to construct an output signal from sub-carriers that are each received by any one of the n antenna branches in the identified group of n antenna branches.

74. An apparatus in accordance with claim 73, wherein the sub-carrier selection diversity module comprises:

n detection statistic stages each configured to compute a detection statistic $\Lambda_{k,l}$ for each of K sub-carriers of the other OFDM signal received for one of the n antenna branches in the identified group of n antenna branches; and

a comparator configured to compare the detection statistics for each of the K sub-carriers of the subsequent OFDM signals received for each



of the n antenna branches in the identified group of n antenna branches with the detection statistics for each of the respective K sub-carriers of the subsequent OFDM signals received for each of the other n antenna branches in the identified group of n antenna branches.

75. An apparatus in accordance with claim 74, wherein the sub-carrier selection diversity module further comprises:

a multiplexer configured to select sub-carriers from one or more of the n antenna branches in the identified group of n antenna branches based on data generated by the comparator to form the output signal.